5. Total Maximum Daily Loads

A TMDL prescribes an upper limit on discharge of a pollutant from all sources so as to assure water quality standards are met. It further allocates this load capacity (LC) among the various sources of the pollutant. Pollutant sources fall into two broad classes: point sources, each of which receives a wasteload allocation (WLA); and nonpoint sources, each of which receives a load allocation (LA). Natural background (NB), when present, is considered part of the LA, but is often broken out on its own because it represents a part of the load not subject to control. Because of uncertainties regarding quantification of loads and the relation of specific loads to attainment of water quality standards, the rules regarding TMDLs (Water quality planning and management, 40 CFR Part 130) require a margin of safety (MOS) be a part of the TMDL.

Practically, the margin of safety is a reduction in the load capacity that is available for allocation to pollutant sources. The natural background load is also effectively a reduction in the load capacity available for allocation to human made pollutant sources. This can be summarized symbolically as the equation: LC = MOS + NB + LA + WLA = TMDL. The equation is written in this order because it represents the logical order in which a loading analysis is conducted. First the load capacity is determined. Then the load capacity is broken down into its components: the necessary margin of safety is determined and subtracted; then natural background, if relevant, is quantified and subtracted; and then the remainder is allocated among pollutant sources. When the breakdown and allocation are completed the result is a TMDL, which must equal the load capacity.

Another step in a loading analysis is the quantification of current pollutant loads by source. This allows the specification of load reductions as percentages from current conditions, considers equities in load reduction responsibility, and is necessary in order for pollutant trading to occur. The load capacity must be based on critical conditions – the conditions when water quality standards are most likely to be violated. If protective under critical conditions, a TMDL will be more than protective under other conditions. Because both load capacity and pollutant source loads vary, and not necessarily in concert, determination of critical conditions can be more complicated than it may appear on the surface.

A load is fundamentally a quantity of a pollutant discharged over some period of time, and is the product of concentration and flow. Due to the diverse nature of various pollutants, and the difficulty of strictly dealing with loads, the federal rules allow for “other appropriate measures” to be used when necessary. These “other measures” must still be quantifiable, and relate to water quality standards, but they allow flexibility to deal with pollutant loading in more practical and tangible ways. The rules also recognize the particular difficulty of quantifying nonpoint loads and allow “gross allotment” as a load allocation where available data or appropriate predictive techniques limit more accurate estimates. For certain pollutants whose effects are long term, such as sediment and nutrients, EPA allows for seasonal or annual loads.

5.1 In-stream Water Quality Targets

In-stream water quality targets for TMDLs are variable depending on the nature of the pollutant. For bacteria, the in-stream target is the water quality standard for recreation uses.

For sediment and nutrients, no standards are available or practical. Thus we rely upon surrogate targets to achieve a level of pollution reduction necessary to achieve full support of beneficial uses. Stream temperatures are highly complicated and although temperature criteria exist, the use of riparian shade targets is a much more practical approach.

Design Conditions

Design conditions are those methods which were used to determine pollutant loads. Design conditions are discussed separately for sediment, temperature, and bacteria in this section.

Sediment

To quantify the seasonal and annual variability and critical timing of sediment loading, climate and hydrology must be considered. This sediment analysis characterizes sediment loads using average annual rates determined from empirical characteristics (i.e. bank erosion, road erosion) that developed over time within the influence of peak and base flow conditions. Annual erosion and sediment delivery are functions of a climate where wet water years typically produce the highest sediment loads. Additionally, the annual average sediment load is not distributed equally throughout the year. Erosion typically occurs during a few critical months. It is difficult to quantify these events, thus a single annual load from each source, the stream banks, roads, and mass failures, is calculated and presumed to represent annual average sediment loading from those sources.

In an attempt to reflect seasonal sediment loading, and current EPA guidance, daily sediment loads were developed for each stream based on sediment load targets. Stream flow data was used to determine sediment loads for each month. Refer to Appendix I for further information regarding these calculations. Although daily sediment load calculations were made the annual sediment load target should be followed due to the natural variability of sediment loading.

Temperature

There are several important contributors of heat to a stream including ground water temperature, air temperature and direct solar radiation (Poole and Berman 2001). Of these, direct solar radiation is the source of heat that is most likely to be controlled or manipulated. The parameters that affect or control the amount of solar radiation hitting a stream throughout its length are shade and stream morphology. Shade is provided by the surrounding vegetation and other physical features such as hillsides, canyon walls, terraces, and high banks. Stream morphology affects how closely riparian vegetation grows together and water storage in the alluvial aquifer. The amount of shade provided by objects other than vegetation is not easy to change or manipulate. This leaves vegetation and morphology as the most likely sources of change in solar loading and, hence, temperature in a stream. The relationship between shade and a stream's temperature in the upper Hangman Creek watershed is briefly examined in Appendix B.

The upper Hangman Creek Watershed Advisory Group (WAG) anticipates private land being managed according to Idaho Forest Practices Act (FPA) regulations. Should existing shade fall below the shade targets set by this TMDL, actions are encouraged to be taken by the land manager/landowner to reestablish vegetation with the goal of accelerating achievement of the shade targets.

Current regulations under the Idaho FPA (IDAPA 20.02.01) do regulate the harvest of timber from the near stream vegetative communities. The FPA specifies that seventy-five percent (75%) of the current shade over a Class I stream be left after timber harvest activities, and that re-entry to the area be limited until shade recovers (IDAPA 20.02.01.07.e.ii). Refer to the Idaho FPA (IDAPA 20.02.01.07.e.ii) for further rules protecting near stream vegetation communities.

Near stream plant community

A riparian area is commonly defined as the transitional zone between the aquatic and terrestrial environments. Riparian areas occur as a belt along the banks of rivers, streams, and lakes. As a transitional zone between aquatic and upland environments, riparian systems often exhibit characteristics of both; but they are not as dry as upland environments and they are not quite as wet as aquatic or wetland systems.

As compared to the adjacent upland plant communities the riparian area allows for certain plant communities to grow that would not be capable of living in the drier upland areas. The vegetation composition differences between upland and riparian areas are particularly obvious in arid states where there are often abrupt shifts in vegetation. In less arid states, the transition between upland and riparian is often much less obvious because upland areas benefit from considerably greater rainfall.

Vegetation influences the physical processes of water movement, nutrient mobilization, and soil deposition, and is also the foundation for various ecological interactions including the formation of terrestrial and aquatic food webs and habitat (FISRWG 1998). Disturbances within plant communities may result in alterations to the flow patterns of surface and ground water, soil composition, shade reduction, and nutrient deposition, which in turn lead to changes in water quantity and quality, stream structure, sedimentation rate, temperature, and nutrient balance.

In upper Hangman Creek the difference between the riparian and upland plant communities is often times indiscernible. The vegetation which provides shade to streams in upper Hangman Creek may consist of riparian or upland plant communities but most often consist of a combination of both. Because of this difficulty the vegetation adjacent to the upper Hangman Creek waterways will be referred to as a riparian plant community.

Potential natural vegetation (PNV)

Depending on how much vertical elevation also surrounds the stream, vegetation further away from the riparian corridor can provide shade. However, riparian vegetation provides a substantial amount of shade on a stream by virtue of its proximity. We can measure the amount of shade that a stream enjoys in a number of ways. Effective shade, that shade provided by all objects that intercept the sun as it makes its way across the sky, can be measured in a given spot with a solar pathfinder or with optical equipment similar to a fish-eye lens on a camera. Effective shade can also be modeled using detailed information about riparian plants and their communities, topography, and the stream's aspect. In addition to shade, canopy cover is a similar parameter that affects solar radiation. Canopy cover is the vegetation that hangs directly over the stream, and can be measured using a densiometer, or estimated visually either on site or on aerial photography. All of these methods tell us information about how much the stream is covered and how much of it is exposed to direct solar radiation.

Potential natural vegetation (PNV) along a stream is that intact riparian plant community that has grown to its fullest extent and has not been disturbed or reduced in anyway. The PNV can be removed by disturbance either naturally (wildfire, disease/old age, wind-blown, wildlife grazing) or anthropogenically (domestic livestock grazing, vegetation removal, erosion). Although PNV is the desired target, it is recognized that PNV conditions seldom exist. Achieving these conditions will provide optimal shade and provide for an additional margin of safety in the TMDL loading calculations. The idea behind PNV as targets for temperature TMDLs is that PNV provides the most shade and the least achievable solar loading to the stream. Anything less than PNV results in the stream heating up from additional solar inputs. We can estimate PNV from models of plant community structure (shade curves for specific riparian plant communities), and we can measure existing vegetative cover or shade. Comparing the two will tell us how much excess solar load the stream is receiving, and what can be done to decrease solar gain.

Existing shade or cover was estimated for upper Hangman Creek above the Tribal boundary and its tributaries from visual observations of aerial photos taken during the 2004 National Agriculture Imagery Program (NAIP). These estimates were field verified by measuring shade with a solar pathfinder at systematically located points along the streams (see below for methodology). PNV targets were determined from an analysis of probable vegetation at these creeks and comparing that to shade curves developed for similar vegetation communities in other TMDLs. A shade curve shows the relationship between effective shade and stream width. As a stream gets wider, the shade decreases as the vegetation has less ability to shade the center of wide streams. As the vegetation gets taller, the more shade the plant community is able to provide at any given channel width. Existing and PNV shade (target effective shade) was converted to solar load from data collected on flat plate collectors at the nearest National Energy Research Laboratory weather stations collecting these data. In this case, an average of the two nearest stations at Kalispell, Montana and Spokane, Washington was used. The difference between existing and potential solar load, assuming existing load is higher, is the reduction necessary to bring the stream back into compliance with water quality standards (see Appendix B). PNV shade, or target effective shade, and loads are assumed to be the natural condition, thus stream temperatures under PNV conditions are considered to be the lowest achievable temperatures (so long as there are no point sources or any other anthropogenic sources of heat in the watershed).

Pathfinder Methodology

The solar pathfinder is a device that allows one to trace the outline of shade producing objects on monthly solar path charts. The percentage of the sun’s path covered by these objects is the effective shade on the stream at the spot that the tracing is made. In order to adequately characterize the effective shade on a reach of stream, ten traces should be taken at systematic or random intervals along the length of the stream in question.

At each sampling location the solar pathfinder should be placed in the middle of the stream about one foot above the water. Follow the manufacturer’s instructions (orient to true south and level) for taking traces. Systematic sampling is easiest to accomplish and still not bias the location of sampling. Start at a unique location such as 100 meters from a bridge or fence line and then proceed upstream or downstream stopping to take additional traces at fixed intervals (e.g. every 100 meters, every half-mile, every degree change on a GPS, every 0.5 mile change on an odometer, etc.). One can also randomly locate points of measurement by generating random numbers to be used as interval distances.

It is a good idea to take notes while taking solar pathfinder traces, and to photograph the stream at several unique locations. Pay special attention to changes in riparian plant communities and what kinds of plant species (the large, dominant, shade producing species) are present. Additionally or as a substitution, one can take densiometer readings at the same location as solar pathfinder traces. This provides the potential to develop relationships between canopy cover and effective shade for a given stream.

Aerial Photo Interpretation

Canopy coverage estimates or expectations of shade based on plant type and density are provided for 200-foot elevation intervals or natural breaks in vegetation density. Each interval is assigned a single value representing the bottom of a 10% canopy coverage or shade class as described below (*adapted from the CWE process, IDL, 2000)*:

Cover class	Typical vegetation type
0 = 0 – 9% cover	agricultural land, denuded areas
10 = 10 –19%	agricultural land, meadows, open areas, clearcuts
20 = 20 – 29%	agricultural land, meadows, open areas, clearcuts
30 = 30 – 39%	agricultural land, meadows, open areas, clearcuts
40 = 40 – 49%	shrublands/meadows
50 = 50 – 59%	shrublands/meadows, open forests
60 = 60 – 69%	shrublands/meadows, open forests
70 = 70 – 79%	forested
80 = 80 – 89%	forested
90 = 90 –100%	forested

The visual estimates of shade in this TMDL were field verified with a solar pathfinder. The pathfinder measures effective shade and is taking into consideration other physical features that block the sun from hitting the stream surface (e.g. hillsides, canyon walls, terraces, man-made structures). The estimate of shade made visually from an aerial photo does not take into account topography or any shading that may occur from physical features other than vegetation. However, research has shown that shade and cover measurements are remarkably similar (OWEB, 2001), reinforcing the idea that riparian vegetation and objects proximal to the stream provide the most shade.

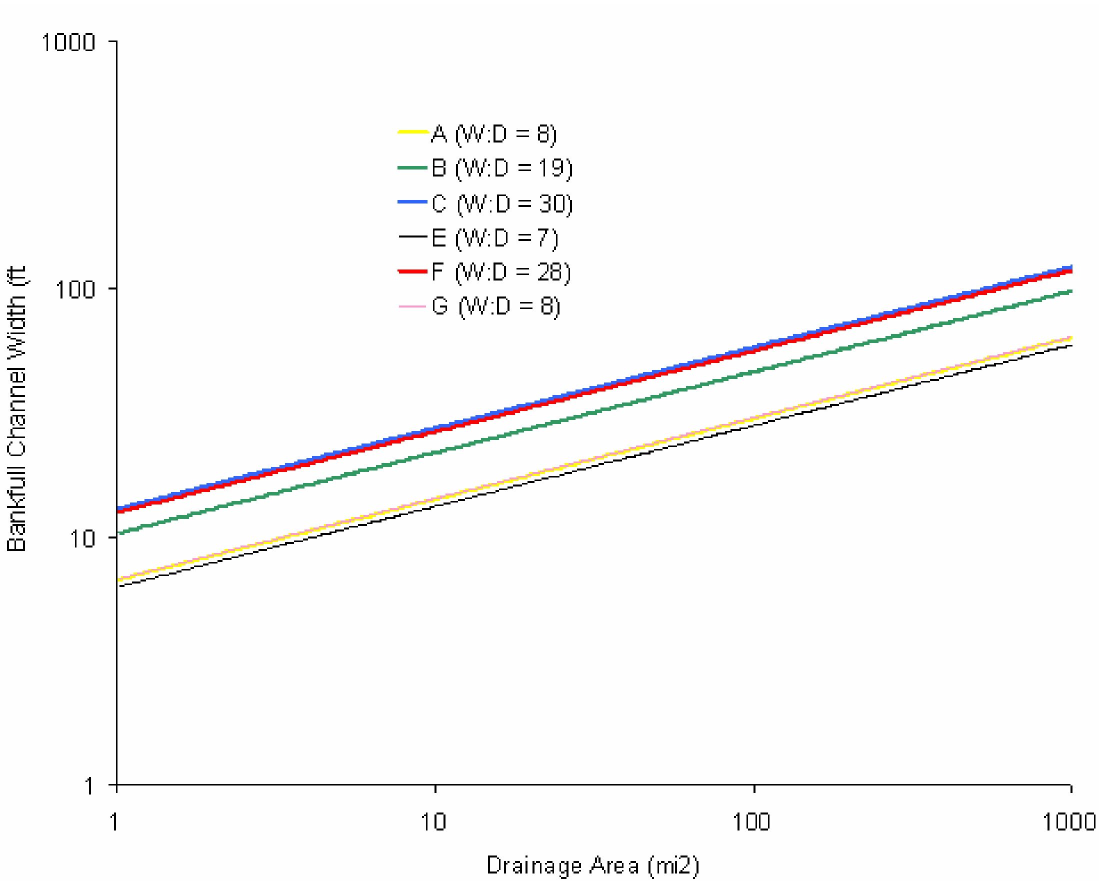
Stream Morphology

Measures of current bankfull width or near stream disturbance zone width may not reflect widths that were present under PNV. As impacts to streams and riparian areas occur, width-to-depth ratios tend to increase such that streams become wider and shallow. Wider streams mean less vegetative cover to provide shading.

Shade target selection, which involves evaluating the amount of shade provided at PNV conditions, necessitates recognition of potential natural stream widths as well. In this TMDL appropriate stream widths for shade target selection were determined from analysis of existing stream widths and the relationship between drainage area and width-to-depth ratios (Rosgen, 1996). Figure 10 (from IDEQ, 2002) shows the relationship between drainage area and bankfull width for the various level 1 Rosgen channel types.

The streams in the upper Hangman Creek watershed are small given that only the portion above the Coeur d'Alene Tribal Reservation is involved. A sliding scale of stream widths was developed for the various streams in question with the lower ends of Hangman Creek and South Fork Hangman Creek receiving a 10 foot (3 m) wide channel (drainage areas for both are approximately 8-10 mi^2 or 5,120-6,400 acres) and decreasing upstream to headwaters areas with 1.5 foot (0.5 m) wide channels. Thus, small headwater streams such as Hill Creek and Bunnel Creek will have natural stream widths of 1.5 feet (0.5 m). Larger headwater streams such as Martin Creek and Conrad Creek will increase from 1.5 feet (0.5 m) in their headwaters to 3 feet (1 m) wide at their mouths. Finally, the largest streams (Hangman Creek and South Fork Hangman Creek) run the gamut from 1.5 feet (0.5 m) in their headwaters, then 3 feet (1 m), 6.5 feet (2 m), and 10 feet (3 m) at their lowest point in this portion of the watershed.

Figure 10. Bankfull Width as a Function of Width to Depth Ratio and Drainage Area.



<u>Bacteria</u>

In the case of bacteria and recreation uses, the warmer months of the year including late spring, summer and early fall are considered the critical time period to protect recreational users of surface waters from bacterial contamination. In this TMDL, bacteria data were collected during summer months so little is known about bacterial contamination in spring following runoff or in the fall. Bacterial contamination is also highly affected by flow. Thus, in this TMDL, bacteria loads are developed based on flow. Subsequent monitoring to implement this bacteria TMDL will require measurements of flow at the same time as bacteria sampling.

In this TMDL, *E. coli* data collected in July and August of 2002 did not have concomitant flow data. However, flow was measured at the bacteria sample locations several days prior to sampling during the BURP crew visits. Flow measured by the BURP crew was 0.9 cfs in Hangman Creek and 0.8 cfs in South Fork Hangman Creek on July 2, 2002. Bacteria sampling commenced on July 8, 2002 and continued approximately every week until August 13, 2002. In order to estimate flow during the bacteria sampling events, flow data from the USGS gauging station (12422950) near Tekoa, Washington (below the confluence of Hangman and Little Hangman Creek) provided by the Coeur d'Alene Tribe, was used to estimate flow at the bacteria sampling locations. Table 8 shows the mean daily flow at the Tekoa gage, the change in flow from one sample date to the next (as a fraction of the difference), and the flow estimates for Hangman Creek and South Fork Hangman Creek based on that change. Negative change, although counterintuitive, results from an increase in flow during the latter date.

Flow at the Tekoa gage decreased from 3.25 cfs on July 2nd to 0.72 cfs on August 2nd with rates of change varying from 29%, 48%, 6%, 13%, and 26% over the range of sample dates. For the remaining three sample dates in August flow increased at the Tekoa gage to 0.9 cfs on August 13th with flow increases ranging from 5% to 11%. These rates of change were applied to the flow measured at the Hangman Creek and South Fork Hangman Creek BURP sites on July 2, 2002. Thus, Hangman Creek's flow decreased from 0.9 cfs to 0.2 cfs, then increased to 0.24 cfs during the course of bacteria sampling. The South Fork's flow decreased from 0.8 cfs to 0.18 cfs, and then increased to 0.22 cfs.

Table 8. Mean daily flow measured at the Tekoa gage and estimated for Hangman Creek and its South Fork.

Mean Daily Flow (cfs)				
Sample Date	Tekoa Gage	Date to Date Change in Flow (as a fraction)	Hangman Creek Estimate	South Fork Hangman Creek Estimate
7/2/2002	3.25		0.90[a]	0.80[a]
7/8/2002	2.31	0.2892	0.64	0.57
7/22/2002	1.19	0.4848	0.33	0.29
7/26/2002	1.12	0.0588	0.31	0.28
7/29/2002	0.976	0.1286	0.27	0.24
8/2/2002	0.724	0.2582	0.20	0.18
8/5/2002	0.802	-0.1077	0.22	0.20
8/9/2002	0.841	-0.0486	0.23	0.21
8/13/2002	0.88	-0.0464	0.24	0.22

a = These are measured flows during BURP visit.

Target Selection

Sediment

Sediment targets for this TMDL are based on stream bank erosion, road erosion, and mass failure quantitative allocations in tons/year. The reduction in stream bank erosion prescribed in this TMDL is directly linked to the improvement of riparian vegetation density to armor stream banks thereby reducing lateral recession, trapping sediment and reducing stream energy, which in turn reduces stream erosivity and instream sediment loading. It is assumed that by reducing chronic sediment, there will be a decrease in subsurface fine sediment that will ultimately improve the status of beneficial uses.

It is assumed that natural background sediment loading rates from bank erosion equate to 80% bank stability as described in Overton and others (1995), where banks are expressed as a percentage of the total estimated bank length. Natural condition stream bank stability potential is generally 80% or greater for Rosgen A, B, and C channel types in plutonic, volcanic, metamorphic, and sedimentary geology types. Therefore, an 80% bank stability target based on stream bank erosion inventories shall be the target for sediment.

Road erosion and mass failure estimates of sediment delivery were determined from the CWE assessment of the upper Hangman Creek area (IDL, 2003). Sediment delivery from road erosion was determined from the CWE score for forest roads and the relationship between these scores and sediment export developed by McGreer (1997).

Forest road sediment yield was estimated using the relationship between the CWE score and the sediment yield per mile of road (Figure 11). The relationship was developed for roads on a Kaniksu granitic terrain in the LaClerc Creek (Washington) watershed (McGreer 1997). Its application to roads on geologies of the upper Hangman Creek conservatively estimates (overestimates) sediment yields from these systems. The watershed CWE score was used to develop sediment tons per mile, which was multiplied by the estimated road mileage.

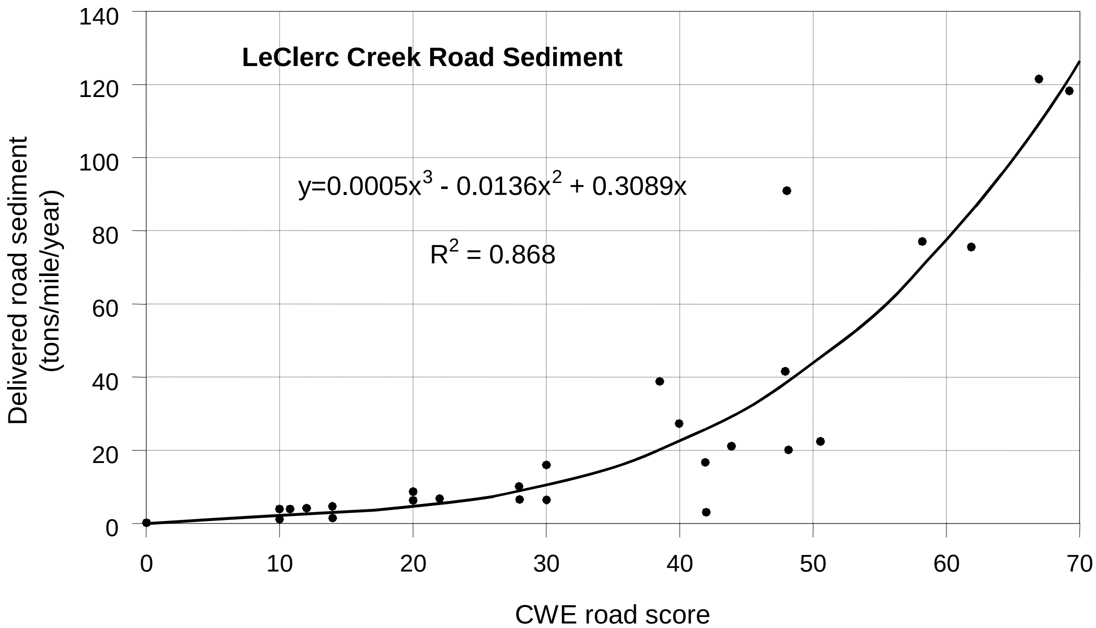


Figure 11. Sediment export from roads based on CWE scores.

Additional research and analysis methods support the use of the sediment export delivery values used to calculate sediment generation associated with forest roads. WEPP:Road is an interface of the Water Erosion Prediction Project (WEPP) soil erosion model that allows users to easily describe numerous road erosion conditions (USFS 1999). When evaluating sediment delivery to the stream using WEPP roads the Moscow, Idaho climate station was used to supply precipitation information to the model. Road width (forty feet), road length (two hundred feet), fill gradient (50%), and fill length (fifteen feet) were held constant. Road design, soil texture, percent rock, buffer gradient and length, road surface, and traffic level were all manipulated. Manipulation of these variables resulted in a predicted forest road erosion rate ranging from 0 tons/mile/year to 11 tons/mile/year, with an average of 3.38 tons/mile/year. The average WEPP Road output of 3.38 tons/mile/year using the McGreer equation is equal to a road CWE score of 15.5. The consistency between the two approaches suggests that the application of the relationship in figure 11 is appropriate.

Manipulation of variables can result in drastically different sediment yields. This variability is most likely what is occurring in upper Hangman Creek. To determine site specific sediment generation from forest roads within upper Hangman Creek extensive monitoring needs to be completed.

The volume estimate and percent delivery from mass failures, provided by the CWE assessment (IDL, 2003) was converted directly to tons of sediment using a bulk density of 100 lbs/ft^3. Target values for road erosion and mass failure are based on the concept of 50% above background is threshold. It is assumed here that background is zero for these sources, which may be accurate for roads, but incorporates a margin of safety for mass failures as no natural mass failures are assumed. Therefore, a target based on 50% reduction in these events was used for this TMDL.

Fifty percent above natural background was chosen as a sediment target following modeling results from EPA approved TMDLs developed for northern Idaho water bodies. EPA approved TMDLs for which 50% above natural background was modeled to be protective include Priest River (IDEQ, 2001), St. Maries River (IDEQ, 2003), St. Joe River (IDEQ, 2003), and the Kootenai/Moyie River TMDL (IDEQ, 2006). Modeling results from the Lower Clark Fork River draft TMDL (2006) also indicate a target of 50% above natural background as protective of all beneficial uses.

All sediment contribution from roads and mass failures were determined to be anthropogenically caused, with no amount contributing to natural background, and existing load reductions set at 50%. This assumption does not account for naturally occurring mass failure events. The small portion of the load calculated above the load capacity for mass failures (0.3% or 3.5 tons) of the total existing load could be considered an additional margin of safety. The IDL CWE (IDL 2003) report conducted within the watershed did include a mass failure hazard rating analysis. The analysis analyzed the topographic, geologic, and soil characteristics of the watershed and determined that the mass failure hazard rating was low. Because of this low rating accounting for any natural occurring mass failures may be an overestimate of sediment contribution.

Temperature

A single effective shade target of 90% was developed for all streams in this portion of the watershed. Because stream widths are small, no greater than 3m, just about any tree or large shrub community, deciduous or conifer is anticipated to provide the maximum amount of shade. Shade curves developed for other TMDLs in the Northwest (South Fork Clearwater, Idaho; Walla Walla River, Oregon; Willamette River, Oregon; Mattole River, N. California) all show that maximum shading occurs at stream widths less than three meters. Because existing shade was evaluated on 10% intervals with the lowest value representing that interval (i.e. 90% represents the shade class of 90% to 100%), the target is also based on this value. Hence the effective shade target for all streams in this TMDL is 90%.

Bacteria

Bacteria targets are set at the water quality standard for recreation uses or 126 cfu/100ml of *E. coli*. For any given flow, the number of colonies the water body can contain and still meet this target is derived from multiplying the flow (converted to milliliters) by 1.26cfu.

Monitoring Points

Sediment

Sediment loadings are based on stream bank erosion inventories conducted on representative reaches, road erosion, and mass failures. Future implementation monitoring should include continued use of erosion inventories on representative reaches in the watershed and the CWE assessment of roads and mass failures. Each reach evaluated in the stream bank inventory for this TMDL represents similar types of reaches in the watershed. It is not necessary to sample these exact locations again. Other reaches for each type represented should be evaluated to take into account variation in the type.

Temperature

Solar loadings in this TMDL are based on aerial photo interpretation. These interpretations are field verified at specific locations. Future monitoring should include continued use of aerial photo interpretation with field verification. Solar pathfinder field verification does not need to take place in exact locations where current field verifications were taken.

Bacteria

Increased monitoring of bacteria is needed to ascertain the source(s) and extent of bacterial contamination in the watershed. Currently it is not known whether the bacteria are from animal or human sources. Future monitoring should include more site specific monitoring, more times of the year, DNA analysis of animal source, and subsequent flow measurements.

5.2 Load Capacity

Loading capacities for pollutants in these TMDLs are based on achieving specific targets. For sediment and bacteria in most cases a 10% margin of safety is taken “off the top” by removing 10% of the loading capacity from consideration. Temperature loading capacities or solar loading capacities are based on potential natural vegetation levels blocking solar radiation. As such, an implicit margin of safety is included in the loading capacity because no less solar loading can be achieved.

Sediment

Bank stability of 80% produces an erosion rate based on the recession rate and stream size evaluated in each stream bank erosion inventory (see Appendix D). Thus, each inventoried reach (Figure 14) and the length of stream that the inventory represents has a proposed erosion rate (tons/mile/year) and a proposed total erosion rate (tons/yr) (see Table 9a). These values as seen on each inventory worksheet and Table 9a represents the loading capacity of the stream. Loading capacities vary from less than 5 tons/mile/year on small forested streams (Bunnel Creek, Hill Creek, and upper Conrad Creek) to 19 tons/mile/year on larger forested segments (upper South Fork Hangman Creek, middle Hangman Creek, lower Conrad Creek, and middle to upper Martin Creek) to greater than 50 tons/mile/year on lower segments of Hangman Creek, South Fork Hangman Creek, and Martin Creek.

The loading capacity of the streams for road erosion and mass failures is based on a 50% above background threshold value (Washington Forest Practices Board, 1995) and previous modeling efforts from within northern Idaho. In this TMDL it is assumed that zero loading from these sources is background. Therefore a reduction of 50% is imposed in this TMDL to help mitigate the effects of human disturbance in the watershed.

Temperature

The loading capacity for stream temperature is based on the solar loading to a stream with 90% effective shade. We use the summer average solar loading (average of six months from April through September) as a benchmark. One hundred percent solar loading to a flat plate collector with zero tilt as measured at the National Renewable Energy Laboratory Spokane station averages 5.7 kWh/m^2/day for this summer period. If 90% of that loading is blocked by effective shade, then only 10% of that loading or 0.57 kWh/m^2/day reaches the stream at target conditions. The loading capacity of 0.57 kWh/m^2/day is listed in Tables 10 through 16 as Potential Summer Load.

<u>Bacteria</u>

The bacteria loading capacity is based on flow (Table 8) and the *E. coli* water quality standard of 126cfu/100ml. Flow (cfs) was converted to milliliters and then multiplied by 1.26. Figures 12 and 13 show the relationship between flows and the number of *E. coli* colonies the stream can contain and still meet the water quality standard. A flow of 1cfs can contain 35,679 cfu of *E. coli* at loading capacity. Figures 11 and 12 also show existing bacteria loads in Hangman Creek and South Fork Hangman Creek based on 5-day geometric means.

Figure 12. Loadings of *E. Coli* bacteria in Hangman Creek based on flow. The loading capacity does not reflect any reductions from a margin of safety.

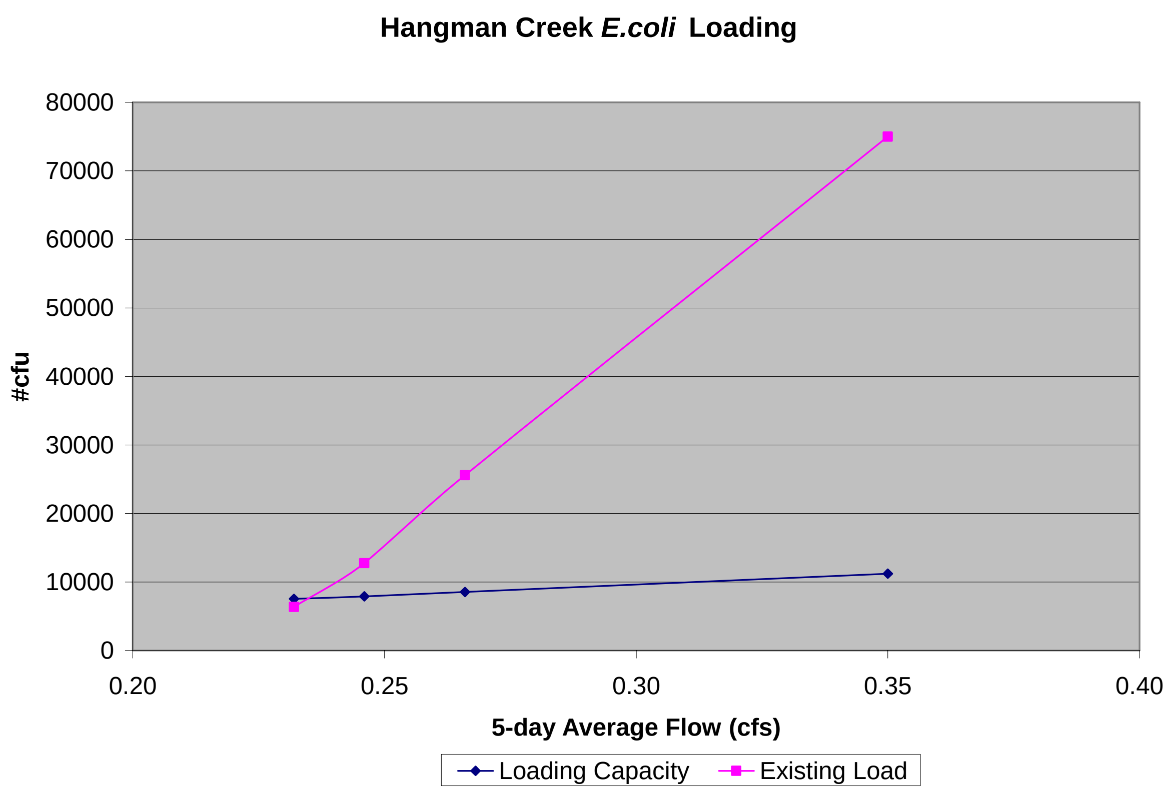
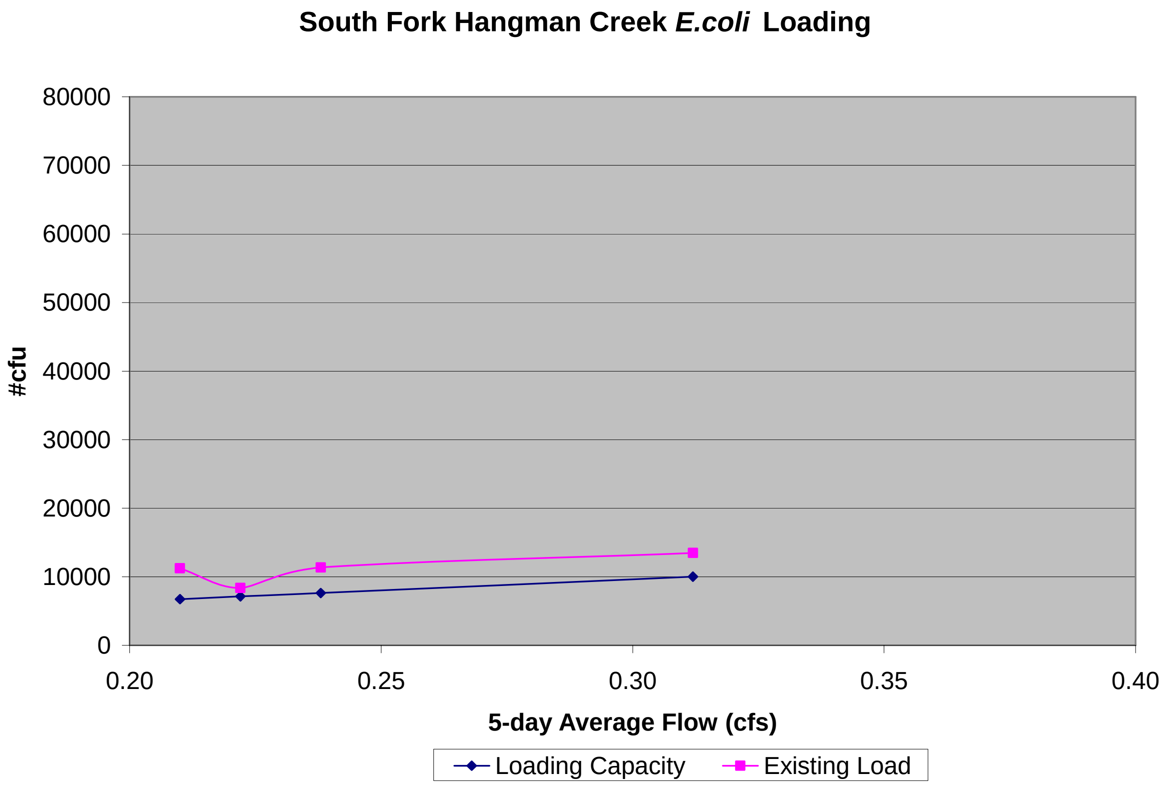


Figure 13. Loadings of *E. Coli* bacteria in South Fork Hangman Creek based on flow. The loading capacity does not reflect any reductions from a margin of safety.



5.3 Estimates of Existing Pollutant Loads

Regulations allow that loadings "...may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading," (Water quality planning and management, 40 CFR § 130.2(I)). An estimate must be made for each point source. Nonpoint sources are typically estimated based on the type of sources (land use) and area (such as a subwatershed), but may be aggregated by type of source or land area. To the extent possible, background loads should be distinguished from human-caused increases in nonpoint loads.

Sediment

Forest road sediment yield was estimated using the relationship between the CWE road score and sediment yield per mile of road developed by McGreer (1998) for the LeClerc Creek watershed. The CWE road score of 17.2 produced by the CWE assessment of the upper Hangman Creek watershed (IDL, 2003) resulted in a sediment yield of 3.8 tons/mile/year. The CWE assessment (IDL, 2003) indicated that there were 71 miles of forest road in the portion of the watershed analyzed. This results in a sediment yield from roads of 270 tons/year (Table 9b).

Three mass failures were evaluated in the upper watershed by the CWE assessment (IDL, 2003). Mass failure volume estimates were 20, 10 and 10 cubic yards (yds^3) with percent delivery ratings of 20%, 5%, and 5%, respectively. The combination results in a total of 5 yds^3 delivered to the streams from mass failure. Using an average bulk density of 100 lbs/ft^3, that 5 yds^3 weighs slightly less than 7 tons (Table 9b).

Existing stream bank erosion rates were measured at eight reaches in the upper Hangman Creek watershed (see Figures 13 and 14). These eight reaches were used to represent larger portions of the upper watershed under evaluation (see Figure 14). For example, Reach 1 was a 785 foot (239 m) stretch of middle Martin Creek that was used to represent 6,562 feet (2,000 m) of middle to upper Martin Creek and 8,858 feet (2,700 m) of middle to lower Conrad Creek; an area of mixed forest and shrub that was deemed similar due to elevation, stream size and history of land use. Reach 2 represents 1,969 feet (600 m) of lower Martin Creek. Reach 3 represents intact forest on 3,117 feet (950 m) of Bunnel Creek, 4,921 feet (1,500 m) of upper Hangman Creek, 5,577 feet (1,700 m) of Hill Creek and 3,609 feet (1,100 m) of upper Conrad Creek. Reach 4 represents gallery forest along roads from 8,858 feet (2,700 m) of the South Fork Hangman Creek and 6,562 feet (2,000 m) of middle Hangman Creek. Reach 5 was measured approximately three miles downstream of the Tribal boundary outside of the upper watershed area under investigation. Reach 5 was used to represent brushy areas at the widest portion of the upper watershed; 3,150 feet (960 m) of lower Hangman Creek and 755 feet (230 m) of lower South Fork Hangman Creek. Reach 6 was measured on lower Tenas Creek, a small tributary to Martin Creek. This reach was sampled in a freshly harvested forest area to provide some idea of erosion from such activities. Reach 6 represents 3,117 feet (950 m) of Tenas Creek. Reach 7 was also sampled in a recently harvested area on upper Bunnel Creek. This reach represents 3,937 feet (1,200 m) of upper Bunnel Creek. Finally, Reach 8 was sampled in a brushy area along lower South Fork Hangman Creek, and was used to represent 6,594 feet (2,010 m) of that creek.

Table 9a. Sediment Loading Analysis for the upper Hangman Creek Watershed. The Proposed Total Erosion includes the removal of 10% as a margin of safety.

Reach Number	Segment Measured	Segments Represented	Existing		Proposed		Percent (%) Reduction
			Erosion Rate (t/mi/yr)	Total Erosion (tons/yr)	Erosion Rate (t/mi/yr)	Total Erosion – 10% MOS (tons/yr)	
1	Upper Martin Creek	Middle to upper Martin, Middle to lower Conrad	22.4	37.5	19.4	29.3	22
2	Lower Martin Creek	Lower Martin Creek	95.9	35.8	52	17.5	51
3	Lower Bunnel Creek	Lower Bunnel, Hill Creek, upper Conrad, upper Hangman	1.7	5.5	4.7	13.8	0
4	Upper South Fork Hangman Creek	Upper South Fork Hangman, middle Hangman	19.1	55.7	19.3	50.8	9
5	Hangman Creek	Lowest portion of Hangman and South Fork Hangman	730.2	435.7	196	116.9*	73
6	Tenas Creek	Lower Tenas Creek	15	8.9	12.8	6.8	23
7	Upper Bunnel Creek	Upper Bunnel Creek	2.3	1.7	4.2	2.8	0
8	Lower South Fork Hangman Creek	Lower South Fork Hangman Creek	137.6	171.8	90.3	101.5	41
Total	Watershed	Above Tribal Boundary		752.6		339.4	55

*No margin of safety has been subtracted from Reach 5 due to over estimation.

Existing erosion rates vary from approximately 2 tons/mile/year in the forested areas of Bunnel Creek, Hill Creek, and upper Conrad and Hangman Creeks to 730 tons/mile/year on lowest portions Hangman and South Fork Hangman Creeks (Table 9a). Middle to upper Martin Creek and middle to lower Conrad Creek erosion rates were near 22 tons/mile/year. Likewise, upper South Fork Hangman Creek and middle Hangman Creek had erosion rates of 19 tons/mile/year. Whereas the lower portions of the South Fork and Martin Creek had rates around 95 to 137 tons/mile/year. The heavily harvested area of Tenas Creek had an erosion rate of 15 tons/mile/year compared to the 2 tons/mile/year on the slightly older harvested area on upper Bunnel Creek.

Table 9b. Sediment Allocations by Source.

Source	Existing Load (tons/year)	Loading Capacity (tons/year)	Reduction (%)
Stream banks	753	339	55
Roads	270	135	50
Mass Failure	7	3.5	50
Total	**1030**	**477.5**	**54**

In terms of total annual erosion, the entire watershed above the Tribal boundary released more than twice as much sediment than load capacity (Table 9b). Reductions in road and mass failure sediment delivery were pre-determined at 50% (Washington Forest Practices Board, 1995). For stream banks, reduction for the whole watershed above the Tribal boundary is about 55%. Martin Creek and most of Conrad Creek together released about 73 tons from their banks compared to the 7 tons/year released from the forested areas around much smaller Bunnel Creek, Hill Creek, upper Conrad Creek, and the very tip of Hangman Creek (Table 9a). Upper South Fork Hangman Creek and middle Hangman Creek together released about 56 tons/year, whereas the lower portion of South Fork Hangman Creek released 172 tons/year alone. The lowest 0.6 miles (966 m) of Hangman Creek and South Fork Hangman Creek released the greatest amount of sediment at 436 tons/year, however, that is based on data collected at Reach 5 several miles below these reaches. It is likely that actual releases from this area are less due to reduced stream flows and slightly better riparian vegetation and bank conditions. This provides a built in margin of safety for Reach 5, thus a 10% MOS was not subtracted from its loading capacity.

Upper Bunnel Creek and Tenas Creek provide data on likely erosion from forest harvest activities on these smaller headwater streams. Erosion from upper Bunnel Creek is less than that from Tenas Creek, which may reflect slight differences in time since harvest, with upper Bunnel Creek having more time to recover.

Temperature

Streams assessed in this portion of the Hangman Creek watershed were assigned existing shade values at natural break intervals (see Figure 13). Existing shade values ranged from 40% to 90%.

Existing summer solar loads were calculated by multiplying the flat plate collector solar load value (5.7 kWh/m^2/day) by one minus the existing shade value (as a fraction) for a particular reach of stream. Thus, if existing shade is 70%, then the existing load is calculated as 1 - 0.7 = 0.3 x 5.7 kWh/m^2/day = 1.71 kWh/m^2/day.

Tables 10 through 16 show existing shade values and their corresponding existing summer solar load for all streams evaluated. Because solar load is provided on an area basis, total stream loads (in kWh/day) were calculated by first deriving the stream reach area (m^2) from the length times stream width, and then multiplying that area times the existing summer load in kWh/m^2/day.

Bacteria

E. coli was sampled eight times over a two month period from July 8, 2002 to August 13, 2002 at two locations (Hangman Creek and South Fork Hangman Creek). To our knowledge no flow measurements were taken at the time of sampling for bacteria. Therefore, in order to produce existing loads the most recent flow measurements taken during BURP monitoring visits (July 2, 2002) were used to estimate flows during bacteria sampling. At that time flow was measured at 0.9cfs and 0.8cfs in Hangman Creek and South Fork Hangman Creek, respectively. Flow was measured during the sampling dates at the Tekoa gage, which was used to produce the relative difference in flow during subsequent bacteria sampling dates. Loadings based on the first through the fourth running geometric mean calculated from the eight samples (Table 6) were produced at these flows and displayed in Table 9c and Figures 12 and 13 (see Appendix F for loading analysis).

Table 9c. Numbers of *E. coli* colonies in stream at loading capacity (minus 10% MOS) and at the four measured geometric means, and the percent (%) reduction necessary to achieve the loading capacity.

Stream	Flow (cfs)	Load Capacity (cfu/cfs at time of bacteria sampling)	Geometric means (cfu/cfs at time of bacteria sampling)	% Reduction
Hangman Creek	0.35	11,203	74,992	85
	0.266	8,542	25,571	67
	0.246	7,899	12,741	38
	0.232	7,450	6,388	0
South Fork Hangman Creek	0.312	10,019	13,477	26
	0.238	7,643	11,355	33
	0.222	7,129	8,374	15
	0.21	6,744	11,251	40

Figure 14. Existing shade values for various reaches in the upper Hangman Creek watershed

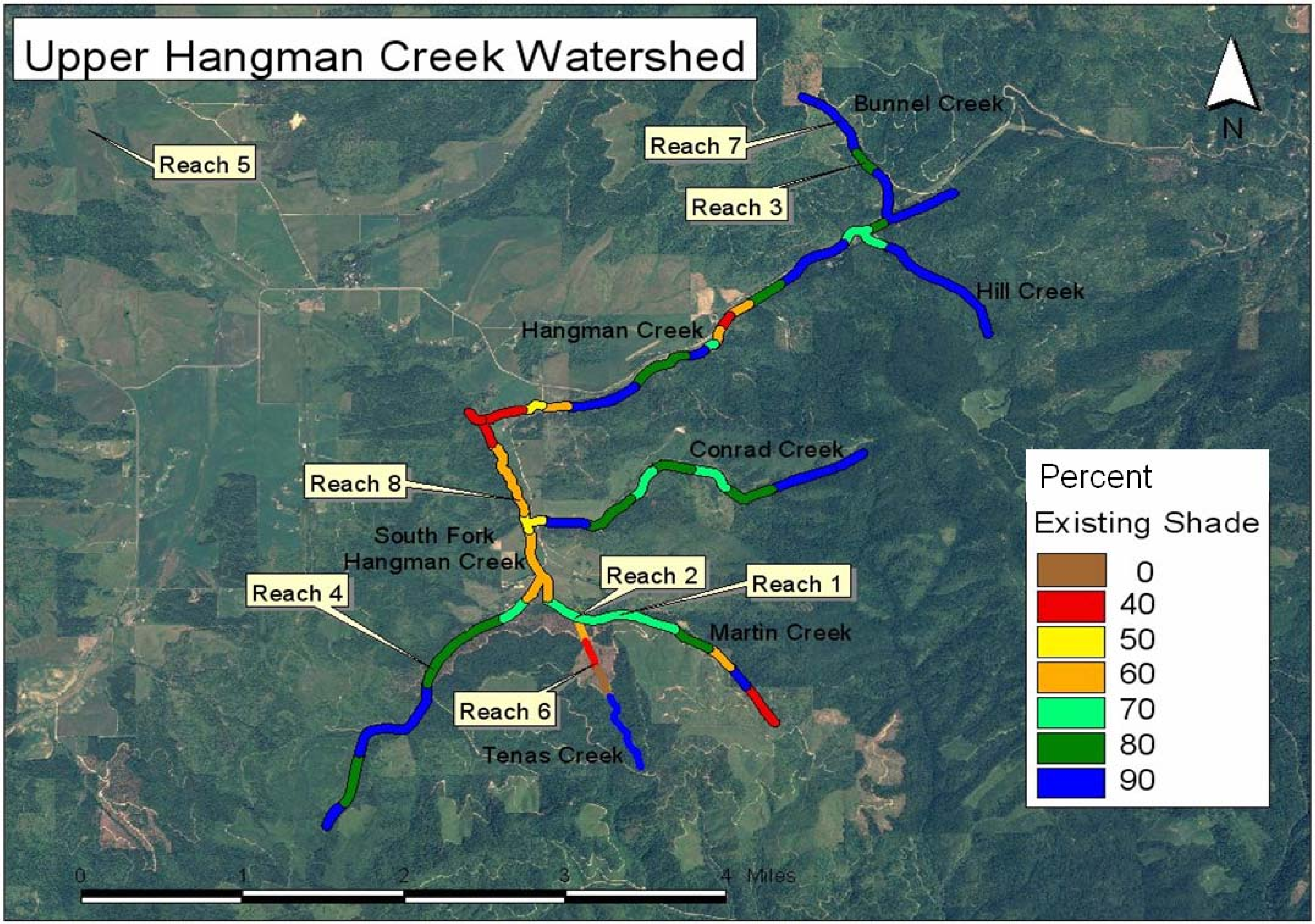


Figure 15. Stream bank erosion representative reaches.

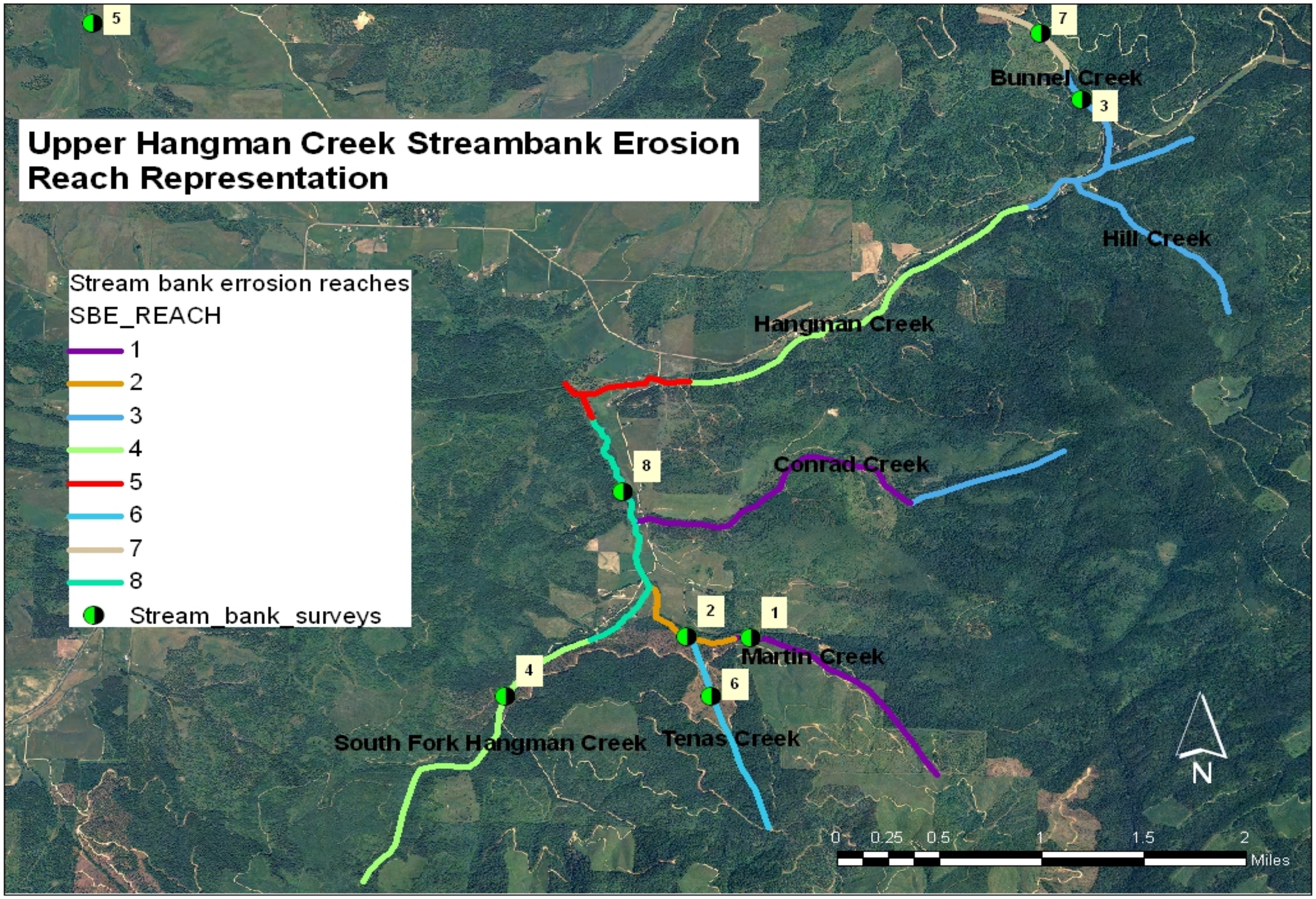


Table 10. Solar loading analysis for Hangman Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
0.5 (headwtr)	0.9	0.57	0.9	0.57	0.00	805	402.5	229.43	0.5	229.43	0
0.2	0.8	1.14	0.9	0.57	-0.57	322	322	367.08	1	183.54	-183.54
0.2	0.7	1.71	0.9	0.57	-1.14	322	322	550.62	1	183.54	-367.08
0.6	0.9	0.57	0.9	0.57	0.00	966	1932	1101.24	2	1101.24	0
0.3	0.8	1.14	0.9	0.57	-0.57	483	966	1101.24	2	550.62	-550.62
0.2	0.6	2.28	0.9	0.57	-1.71	322	644	1468.32	2	367.08	-1101.24
0.1	0.4	3.42	0.9	0.57	-2.85	161	322	1101.24	2	183.54	-917.7
0.1	0.6	2.28	0.9	0.57	-1.71	161	322	734.16	2	183.54	-550.62
0.15	0.7	1.71	0.9	0.57	-1.14	241	723	1236.33	3	412.11	-824.22
0.1	0.9	0.57	0.9	0.57	0.00	161	483	275.31	3	275.31	0
0.3	0.8	1.14	0.9	0.57	-0.57	483	1449	1651.86	3	825.93	-825.93
0.4	0.9	0.57	0.9	0.57	0.00	644	1932	1101.24	3	1101.24	0
0.2	0.6	2.28	0.9	0.57	-1.71	322	966	2202.48	3	550.62	-1651.86
0.15	0.5	2.85	0.9	0.57	-2.28	241	723	2060.55	3	412.11	-1648.44
0.3 (boundary)	0.4	3.42	0.9	0.57	-2.85	483	1449	4955.58	3	825.93	-4129.65
Average	**0.7**	**1.7**	**0.9**	**0.6**	**-1.1**	**Total**	**12957.5**	**20136.7**		**7385.8**	**-12750.9**

Table 11. Solar loading analysis for South Fork Hangman Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load ($kWh/m^2/day$)	Target or Potential Shade (fraction)	Potential Summer Load ($kWh/m^2/day$)	Potential Load minus Existing load ($kWh/m^2/day$)	Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
0.5(headwtr)	0.9	0.57	0.9	0.57	0.00	805	402.5	229.43	0.5	229.43	0.00
0.3	0.8	1.14	0.9	0.57	-0.57	483	241.5	275.31	0.5	137.66	-137.66
0.7	0.9	0.57	0.9	0.57	0.00	1127	1127	642.39	1	642.39	0.00
0.7	0.8[a]	1.14	0.9	0.57	-0.57	1127	1127	1284.78	1	642.39	-642.39
0.3	0.7	1.71	0.9	0.57	-1.14	483	483	825.93	1	275.31	-550.62
0.5	0.6	2.28	0.9	0.57	-1.71	805	1610	3670.80	2	917.70	-2753.10
0.1	0.5	2.85	0.9	0.57	-2.28	161	322	917.70	2	183.54	-734.16
0.5	0.6[b]	2.28	0.9	0.57	-1.71	805	2415	5506.20	3	1376.55	-4129.65
0.2(mouth)	0.4	3.42	0.9	0.57	-2.85	322	966	3303.72	3	550.62	-2753.10
Average	**0.7**	**1.8**	**0.9**	**0.6**	**-1.2**	**Total**	**8694**	**16656.3**		**4955.6**	**-11700.7**

[a] solar pathfinder measurements = 88.8%; [b] solar pathfinder measurements = 61.6%

Table 12. Solar loading analysis for Hill Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load ($kWh/m^2/day$)	Target or Potential Shade (fraction)	Potential Summer Load ($kWh/m^2/day$)	Potential Load minus Existing load ($kWh/m^2/day$)	Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
1	0.9	0.57	0.9	0.57	0.00	1609	804.5	458.57	0.5	458.57	0.00
0.2	0.7	1.71	0.9	0.57	-1.14	322	161	275.31	0.5	91.77	-183.54
Average	**0.8**	**1.1**	**0.9**	**0.6**	**-0.6**	**Total**	**965.5**	**733.9**		**550.3**	**-183.5**

Table 13. Solar loading analysis for Conrad Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
0.7(headwtr)	0.9	0.57	0.9	0.57	0.00	1127	563.5	321.20	0.5	321.20	0.00
0.3	0.8	1.14	0.9	0.57	-0.57	483	241.5	275.31	0.5	137.66	-137.66
0.3	0.7	1.71	0.9	0.57	-1.14	483	483	825.93	1	275.31	-550.62
0.2	0.8	1.14	0.9	0.57	-0.57	322	322	367.08	1	183.54	-183.54
0.2	0.7	1.71	0.9	0.57	-1.14	322	322	550.62	1	183.54	-367.08
0.4	0.8	1.14	0.9	0.57	-0.57	644	644	734.16	1	367.08	-367.08
0.3	0.9	0.57	0.9	0.57	0.00	483	483	275.31	1	275.31	0.00
0.1	0.5	2.85	0.9	0.57	-2.28	161	161	458.85	1	91.77	-367.08
Average	**0.8**	**1.4**	**0.9**	**0.6**	**-0.8**	**Total**	**3220**	**3808.5**		**1835.4**	**-1973.1**

Table 14. Solar loading analysis for Bunnel Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load (kWh/m^2/day)	Target or Potential Shade (fraction)	Potential Summer Load (kWh/m^2/day)	Potential Load minus Existing load (kWh/m^2/day)	Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
0.6	0.9[a]	0.57	0.9	0.57	0.00	966	483	275.31	0.5	275.31	0.00
0.2	0.8[b]	1.14	0.9	0.57	-0.57	322	161	183.54	0.5	91.77	-91.77
0.3	0.9	0.57	0.9	0.57	0.00	483	241.5	137.66	0.5	137.66	0.00
Average	**0.9**	**0.8**	**0.9**	**0.6**	**-0.2**	**Total**	**885.5**	**596.5**		**504.7**	**-91.8**

[a] solar pathfinder measurements = 90.1%; [b] solar pathfinder measurements = 88.5%

Table 15. Solar loading analysis for Martin Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load ($kWh/m^2/day$)	Target or Potential Shade (fraction)	Potential Summer Load ($kWh/m^2/day$)	Potential Load minus Existing load ($kWh/m^2/day$)	Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
0.2(headwtr)	0.4	3.42	0.9	0.57	-2.85	322	161	550.62	0.5	91.77	-458.85
0.2	0.9	0.57	0.9	0.57	0.00	322	161	91.77	0.5	91.77	0.00
0.2	0.6	2.28	0.9	0.57	-1.71	322	161	367.08	0.5	91.77	-275.31
0.15	0.8	1.14	0.9	0.57	-0.57	241	120.5	137.37	0.5	68.69	-68.69
0.8	0.7[a]	1.71	0.9	0.57	-1.14	1287	1287	2200.77	1	733.59	-1467.18
0.2(mouth)	0.6	2.28	0.9	0.57	-1.71	322	322	734.16	1	183.54	-550.62
Average	**0.7**	**1.9**	**0.9**	**0.6**	**-1.3**	**Total**	**2212.5**	**4081.8**		**1261.1**	**-2820.6**

[a] solar pathfinder measurements = 72.3%

Table 16. Solar loading analysis for Tenas Creek.

Segment Length (~miles)	Existing Shade (fraction)	Existing Summer Load ($kWh/m^2/day$)	Target or Potential Shade (fraction)	Potential Summer Load ($kWh/m^2/day$)	Potential Load minus Existing load ($kWh/m^2/day$)	Segment Length (meters)	Segment Area (m^2)	Existing Summer Load (kWh/day)	Natural Stream Width (m)	Potential Summer Load (kWh/day)	Potential Load minus Existing Load (kWh/day)
0.6(headwtr)	0.9	0.57	0.9	0.57	0.00	966	483	275.31	0.5	275.31	0.00
0.2	0	5.7	0.9	0.57	-5.13	322	161	917.70	0.5	91.77	-825.93
0.2	0.4[a]	3.42	0.9	0.57	-2.85	322	161	550.62	0.5	91.77	-458.85
0.2(mouth)	0.6	2.28	0.9	0.57	-1.71	322	161	367.08	0.5	91.77	-275.31
Average	**0.5**	**3.0**	**0.9**	**0.6**	**-2.4**	**Total**	**966**	**2110.7**		**550.6**	**-1560.1**

[a] solar pathfinder measurements = 43.9%

5.4 Load Allocation

There are no known or anticipated point sources of pollutants in this portion of the watershed. Therefore all load allocations are for nonpoint sources and there are no wasteload allocations. No attempt was made to differentiate between different activities or sources. Therefore, the entire available loads are allocated as a whole to the nonpoint source activities and background conditions that may create the pollutant.

Sediment

The loading capacity in Table 9b is assumed to be the available loading capacity or the stream bank loading capacity minus a 10% margin of safety, and represents the available sediment load to be allocated. Because loading capacities for roads and mass failures were not determined, a threshold reduction of 50% was applied (Washington Forest Practices Board, 1995). Intensive row crop farming does not occur in this portion of the watershed. It is assumed that negligible amounts of sediment are entering the streams as runoff from the small amount of pasture land, and that the majority of sediment loading comes from stream banks, roads, and mass failures as the result of bank perturbations or increased hydrology or runoff volumes from land use activities. Therefore, the available loading capacity is allocated to these three nonpoint sources. It is implied that all nonpoint source activities should not increase bank erosion greater than the 80% bank stability target, and that forest land use activities should reduce road and mass failure sediment delivery by 50%.

All streams except Bunnel Creek require a reduction in existing stream bank sediment loading to achieve loading capacity (minus 10% MOS) (Table 9a). Reach 4 representing upper South Fork Hangman Creek and middle Hangman Creek had an existing erosion rate (19.1 tons/mile/year) slightly less than its proposed erosion rate (19.3 tons/mile/year), however, due to the removal of 10% of the proposed total for a MOS, existing total erosion was slightly greater than proposed total erosion resulting in the need for 9% reduction. Lower Hangman Creek, lower South Fork Hangman Creek, and lower Martin Creek require the largest reduction in sediment loading to meet targets. The watershed as a whole above the Tribal boundary requires a 54% reduction in sediment loading to meet loading capacity (Table 9b).

Temperature

All streams require some reduction in solar loading to achieve loading capacity. In Tables 10 through 16 existing summer load was subtracted from potential summer load to reflect the amount of load reduction necessary to achieve potential or target loads. Bunnel Creek and Hill Creek require the least with 15% and 25% reduction, respectively. Percent reductions in summer load to achieve potential load for the remaining streams are 52% for Conrad Creek, 63% for Hangman Creek, 69% for Martin Creek, 70% for South Fork Hangman Creek, and 74% for Tenas Creek.

The loading analysis is based on effective shade provided by riparian vegetation. The load allocation is to nonpoint source activities and background conditions that may have an effect on riparian vegetation and its shading potential. It is implied that nonpoint source activities should not reduce effective shade below potential natural vegetation target levels.

Because potential summer loads are based on the concept of achieving shade levels under potential natural vegetation, an inherent margin of safety is implied as no better shade conditions are considered achievable.

Bacteria

Because sources are not often continuous in their discharge and bacteria are not long-lived, bacteria concentrations vary considerably from one time period to the next. This is reflected in the changing geometric mean throughout the sampling period in Hangman Creek and South Fork Hangman Creek (Table 6). Percent reductions in bacteria numbers necessary to achieve loading capacities (minus a 10% MOS) vary for each geometric mean calculated (Table 9c). In Hangman Creek, necessary reductions steadily decline through the sampling period from an 85% reduction for the first geometric mean down to 0% reductions for the fourth geometric mean. In the South Fork, this relationship does not exist with the fourth geometric mean showing the highest necessary reduction (40%) and the other geo-means variable (26%, 33%, and 15% reductions necessary for the first through the third geo-means, respectively).

The sources of the bacterial contamination are not known. To our knowledge there are no confined animal feeding operations of any size in the upper watershed. However, there may be a few barnyard or pastured animals with direct access to the creeks. Bauer and Wilson (1983) suspected that bacterial contamination in the Hangman Creek watershed was from human sources, most likely aging or malfunctioning septic systems resulting in discharge to the creeks. However, there are not many homes in this portion of the watershed and the problem is not likely due to a concentration of malfunctioning systems.

Substantial additional work needs to be done to isolate the source or sources of bacterial contamination in these creeks. That work includes more site specific sampling and possibly DNA analysis to determine the animal source of the *E. coli* bacteria.

Margin of Safety (MOS)

Stream bank sediment and bacteria loading analyses included a 10% margin of safety by removing 10% of the loading capacity from consideration. Reach 5 calculations of sediment loading did not have a 10% MOS removed because the erosion inventory was based on an area further downstream that is likely to have greater erosion. Thus, an implicit margin of safety is contained within the erosion inventory for Reach 5. For temperature, an inherent margin of safety is implied as no better shade conditions are considered achievable.

Seasonal Variation

Sediment delivery to a stream is highly coupled to seasonal events. The majority of bank erosion and sediment delivery occurs during high runoff, high flow events associated with spring snowmelt and rains. It is often difficult to monitor these events, thus sediment loading analysis is based on sediment delivery from stream banks integrated over an entire year. In an attempt to reflect seasonal sediment loading, and current EPA guidance, daily sediment loads were developed for each stream based on sediment load targets. Stream flow data was used to determine sediment loads for each month. Refer to Appendix I for further information regarding these calculations. Although daily sediment load calculations were made the annual sediment load target should be followed due to the natural variability of sediment loading.

Temperature problems are associated with the certain times of the year that water quality criteria for temperature apply. Water temperatures increase in response to warming air temperatures in spring and summer. Critical time periods for water temperature are during spring and fall salmonid spawning time periods, as well as during peak temperatures in mid summer. Effective shade and its associated riparian community and bank stability, helps keep water cool during warming trends in spring summer and early fall.

Bacterial contamination in streams can be highly variable depending on types of releases, the bacteria's short lived nature, and seasonal hydrology. The summer sampling that has occurred, the results of which have been used in this loading analysis, may be the result of summer low flow conditions. One cannot conclude from these data that *E. coli* contamination is high during other times of the year. Much more sampling is needed to adequately characterize the nature of bacterial contamination throughout the year.

Reasonable Assurance

All allocations are directed at nonpoint source activities. There are no known point sources in this portion of the Hangman Creek watershed. Sediment loading is based on stream bank erosion inventories, road, and mass failure assessments. All future monitoring should include stream bank erosion inventories, road, and mass failure assessments in affected reaches. Additional monitoring to verify impacts to or improvements of beneficial uses can include depth fines monitoring in spawning gravels.

Temperature monitoring should include measurements of effective shade and water temperature continuous recording instruments in affected reaches.

Bacteria monitoring should expand to include all times of the year, more site specific monitoring in an effort to locate specific sources of bacteria, and DNA analysis to determine animal origin of bacteria.

Background

Sediment and temperature TMDLs are based on the concept of meeting background conditions. Sediment targets (80% bank stability) that erosion inventories are based on imply that stream banks are 80% stable under natural conditions. There is no allowance in this sediment TMDL for disturbance of stream banks above background conditions.

Temperature targets are based on achieving potential natural vegetation effective shade levels. There is no allowance in this temperature TMDL for disturbance of riparian shade above these natural conditions.

The bacteria TMDL is based on existing water quality standards to protect recreation uses of these water bodies. Background bacteria conditions are unknown but should be investigated. *E. coli* TMDL levels should be adjusted based on the source or sources of the bacterium.

Reserve

No reserves for future pollutant additions have been made in these TMDLs. All pollutant levels are based on achieving background riparian and stream bank conditions or achieving bacterial standards.

Construction Storm Water and TMDL Waste Load Allocations

Construction Storm Water

The Clean Water Act requires operators of construction sites to obtain permit coverage to discharge storm water to a water body or to a municipal storm sewer. In Idaho, EPA has issued a general permit for storm water discharges from construction sites. In the past storm water was treated as a non-point source of pollutants. However, because storm water can be managed on site through management practices or when discharged through a discrete conveyance such as a storm sewer, it now requires a National Pollution Discharge Elimination System (NPDES) Permit.

The Construction General Permit (CGP)

If a construction project disturbs more than one acre of land (or is part of larger common development) that will disturb more than one acre), the operator is required to apply for permit coverage from EPA after developing a site-specific Storm Water Pollution Prevention Plan.

Storm Water Pollution Prevention Plan (SWPPP)

In order to obtain the Construction General Permit operators must develop a site-specific Storm Water Pollution Prevention Plan. The operator must document the erosion, sediment, and pollution controls they intend to use, inspect the controls periodically and maintain the best management practices (BMPs) through the life of the project.

Construction Storm Water Requirements

When a stream is on Idaho's impaired waters list and has a TMDL developed DEQ may incorporates a gross waste load allocation (WLA) for anticipated construction storm water activities. TMDLs developed now and in the past that do not have a WLA for construction storm water activities will be considered in compliance with provisions of the TMDL if they obtain a CGP under the NPDES program and implement the appropriate Best Management Practices.

Typically there are specific requirements you must follow to be consistent with any local pollutant allocations. Many communities throughout Idaho are currently developing rules for post-construction storm water management. Sediment is usually the main pollutant of concern in storm water from construction sites. The application of specific best management practices from *Idaho's Catalog of Storm Water Best Management Practices for Idaho Cities and Counties* is generally sufficient to meet the standards and requirements of the General Construction Permit, unless local ordinances have more stringent and site specific standards that are applicable.

5.5 Implementation Strategies

DEQ and designated management agencies (DMA) responsible for TMDL implementation will make every effort to address past, present, and future pollution problems in an attempt to link them to watershed characteristics and management practices designated to improve water quality and restore the beneficial uses of the water body. Any and all solutions to help restore beneficial uses of a stream will be considered as part of a TMDL implementation plan in an effort to make the process as effective and cost efficient as possible. Using additional information collected during the implementation phase of the TMDL, DEQ and the designated management agencies will continue to evaluate suspect sources of impairment and develop management actions appropriate to deal with these issues.

DEQ recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows that the TMDL goals are not being met or significant progress is not being made toward achieving the goals.

Time Frame

Five years has been allotted for meeting load allocations for bacteria after implementation actions have been completed.

For sediment, twenty years after implementation strategies have been implemented has been allotted for meeting load allocations. This time frame should allow for two to three large channel forming events to occur in the stream.

Twenty years has been allotted to reach PNV shade levels, however, a substantial time frame may be needed to reach PNV after implementation strategies have been completed.

Approach

TMDLs will be implemented through continuation of ongoing pollution control activities in the watershed. The designated WAG, DMAs, and other appropriate public process participants, are expected to:

- Develop best management practices (BMPs) to achieve load allocations.
- Give reasonable assurance that management measures will meet load allocations through both quantitative and qualitative analysis of management measures.
- Adhere to measurable milestones for progress.
- Develop a timeline for implementation, with reference to costs and funding.
- Develop a monitoring plan to determine if BMPs are being implemented, if individual BMPs are effective, if load allocations and waste load allocations are being met and whether or not water quality standards are being met.

The designated management agencies will recommend specific control actions and will then submit the implementation plan to DEQ. DEQ will act as a repository for approved implementation plans and conduct 5-year reviews of progress toward TMDL goals.

Responsible Parties

In addition to the designated management agencies, the public, through the WAG and other equivalent processes or organizations, will be provided with opportunities to be involved in developing the implementation plan to the maximum extent practical.

Monitoring Strategy

Monitoring will be conducted using the DEQ-approved monitoring procedure at the time of sampling.

5.6 Conclusions

Water body assessment unit ID17010306PN001_02 includes tributaries to Hangman Creek (Bunnel Creek, Hill Creek, South Fork Hangman Creek, Martin Creek, Conrad Creek, and Tenas Creek) and Hangman Creek itself above the confluence with South Fork Hangman Creek. This assessment unit was assessed in 2002 and subsequently listed for temperature. Water body assessment unit ID17010306PN001_03 includes the mainstem Hangman Creek from its confluence with the South Fork Hangman Creek downstream into the Coeur d'Alene Tribal Reservation boundary. This assessment unit retained the original 1998 §303(d) listing for habitat alteration, sediment, bacteria, and nutrients. Due to downstream conditions and the availability of recent data, it was decided that all listed pollutants would be analyzed in all streams, Hangman Creek proper from its source to the Tribal boundary and associated tributaries.

No TMDL was completed for habitat alteration as a matter of DEQ policy. Additionally, due to recent data showing low levels of total phosphorus, it is recommended that this portion of the Hangman Creek watershed be de-listed for nutrients. TMDLs have been completed on all streams for sediment and temperature, and on Hangman Creek and South Fork Hangman Creek for bacteria.

The methods used to quantify pollutant loads (sediment, temperature and bacteria) for development of this TMDL are not intended to be used to quantify site specific pollutant reductions associated with TMDL implementation activities. Rather, the best available method shall be used when calculating load reductions.

The goal of the methods used to quantify sediment and bacteria loads was to estimate current pollutant loads as of April 2005 and existing shade in June 2004. Load reductions made after April 2005 addressing sediment and bacteria, and June 2004 addressing temperature can be applied towards the Hangman Creek TMDL implementation goals.

Table 17. Summary of assessment outcomes.

Stream	Assessment Unit	Pollutant	TMDL(s) Analysis Completed	Recommended changes to the Integrated Report	Justification
Hangman Creek	ID17010306PN001_03	Sediment	Yes	Move to section 4a[1] of Integrated Report	TMDL analysis completed
Hangman Creek	ID17010306PN001_03	Bacteria	Yes	Move to section 4a[1] of Integrated Report	TMDL analysis completed
Hangman Creek	ID17010306PN001_03	Nutrients	No	Delist	Most recent data show attainment of Idaho water quality standard
Hangman Creek	ID17010306PN001_03	Temperature	Yes	Add to Section 5[2] of Integrated Report	Most recent data shows exceedances of Idaho water quality standards
Hangman Creek[3]	ID17010306PN001_02	Temperature	Yes	Move to section 4a[1] of Integrated Report	TMDL analysis completed
Hangman Creek[3]	ID17010306PN001_02	Sediment	Yes	Add to Section 5[2] of Integrated Report	Most recent data shows exceedances of Idaho water quality standards
Hangman Creek[3]	ID17010306PN001_02	Bacteria	Yes	Add to Section 5[2] of Integrated Report	Most recent data shows exceedances of Idaho water quality standards

[1] Section 4a of Integrated Report, Rivers with EPA Approved TMDLs.
[2] Section 5 of Integrated Report, Idaho's Impaired Waters list.
[3] Includes the following tributaries to Hangman Creek below the confluence with the South Fork Hangman Creek – Hangman Creek, South Fork Hangman Creek, Tenas Creek, Martin Creek, Conrad Creek, Hill Creek, Bunnel Creek.

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GIS Coverages

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Glossary

305(b)

Refers to section 305 subsection “b” of the Clean Water Act. The term “305(b)” generally describes a report of each state’s water quality and is the principle means by which the U.S. Environmental Protection Agency, Congress, and the public evaluate whether U.S. waters meet water quality standards, the progress made in maintaining and restoring water quality, and the extent of the remaining problems.

§303(d)

Refers to section 303 subsection “d” of the Clean Water Act. 303(d) requires states to develop a list of water bodies that do not meet water quality standards. This section also requires total maximum daily loads (TMDLs) be prepared for listed waters. Both the list and the TMDLs are subject to U.S. Environmental Protection Agency approval.

Adsorption

The adhesion of one substance to the surface of another. Clays, for example, can adsorb phosphorus and organic molecules

Aeration

A process by which water becomes charged with air directly from the atmosphere. Dissolved gases, such as oxygen, are then available for reactions in water.

Aerobic

Describes life, processes, or conditions that require the presence of oxygen.

Alevin

A newly hatched, incompletely developed fish (usually a salmonid) still in nest or inactive on the bottom of a water body, living off stored yolk.

Algae

Non-vascular (without water-conducting tissue) aquatic plants that occur as single cells, colonies, or filaments.

Alluvium

Unconsolidated recent stream deposition.

Ambient

General conditions in the environment (Armantrout 1998). In the context of water quality, ambient waters are those representative of general conditions, not associated with

	episodic perturbations or specific disturbances such as a wastewater outfall (EPA 1996).
Anaerobic	Describes the processes that occur in the absence of molecular oxygen and describes the condition of water that is devoid of molecular oxygen.
Anthropogenic	Relating to, or resulting from, the influence of human beings on nature.
Aquatic	Occurring, growing, or living in water.
Aquifer	An underground, water-bearing layer or stratum of permeable rock, sand, or gravel capable of yielding of water to wells or springs.
Assemblage (aquatic)	An association of interacting populations of organisms in a given water body; for example, a fish assemblage or a benthic macroinvertebrate assemblage (also see Community) (EPA 1996).
Assessment Unit (AU)	A segment of a water body that is treated as a homogenous unit, meaning that any designated uses, the rating of these uses, and any associated causes and sources must be applied to the entirety of the unit.
Assimilative Capacity	The ability to process or dissipate pollutants without ill effect to beneficial uses.
Bankfull width	The stream stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure.
Bedload	Material (generally sand-sized or larger sediment) that is carried along the streambed by rolling or bouncing.
Beneficial Use	Any of the various uses of water, including, but not limited to, aquatic life, recreation, water supply, wildlife habitat, and aesthetics, which are recognized in water quality standards.

Beneficial Use Reconnaissance Program (BURP)
A program for conducting systematic biological and physical habitat surveys of water bodies in Idaho. BURP protocols address lakes, reservoirs, and wadeable streams and rivers

Best Management Practices (BMPs)
Structural, nonstructural, and managerial techniques that are effective and practical means to control nonpoint source pollutants.

Biochemical Oxygen Demand (BOD)
The amount of dissolved oxygen used by organisms during the decomposition (respiration) of organic matter, expressed as mass of oxygen per volume of water, over some specified period of time.

Biological Integrity
1) The condition of an aquatic community inhabiting unimpaired water bodies of a specified habitat as measured by an evaluation of multiple attributes of the aquatic biota (EPA 1996). 2) The ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the natural habitats of a region (Karr 1991).

Biomass
The weight of biological matter. Standing crop is the amount of biomass (e.g., fish or algae) in a body of water at a given time. Often expressed as grams per square meter.

Biota
The animal and plant life of a given region.

Clean Water Act (CWA)
The Federal Water Pollution Control Act (commonly known as the Clean Water Act), as last reauthorized by the Water Quality Act of 1987, establishes a process for states to use to develop information on, and control the quality of, the nation's water resources.

Coliform Bacteria
A group of bacteria predominantly inhabiting the intestines of humans and animals but also found in soil. Coliform bacteria are commonly used as indicators of the possible presence of pathogenic organisms (also see Fecal Coliform Bacteria, *E. Coli*, and Pathogens).

Colluvium
Material transported to a site by gravity.

Term	Definition
Community	A group of interacting organisms living together in a given place.
Criteria	In the context of water quality, numeric or descriptive factors taken into account in setting standards for various pollutants. These factors are used to determine limits on allowable concentration levels, and to limit the number of violations per year. The U.S. Environmental Protection Agency develops criteria guidance; states establish criteria.
Cubic Feet per Second	A unit of measure for the rate of flow or discharge of water. One cubic foot per second is the rate of flow of a stream with a cross-section of one square foot flowing at a mean velocity of one foot per second. At a steady rate, once cubic foot per second is equal to 448.8 gallons per minute and 10,984 acre-feet per day.
Decomposition	The breakdown of organic molecules (e.g., sugar) to inorganic molecules (e.g., carbon dioxide and water) through biological and nonbiological processes.
Depth Fines	Percent by weight of particles of small size within a vertical core of volume of a streambed or lake bottom sediment. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 6.5 millimeters depending on the observer and methodology used. The depth sampled varies but is typically about one foot (30 centimeters).
Designated Uses	Those water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act.
Discharge	The amount of water flowing in the stream channel at the time of measurement. Usually expressed as cubic feet per second (cfs).
Dissolved Oxygen (DO)	The oxygen dissolved in water. Adequate DO is vital to fish and other aquatic life.

Disturbance	Any event or series of events that disrupts ecosystem, community, or population structure and alters the physical environment.
E. coli	Short for *Escherichia coli*, *E. coli* are a group of bacteria that are a subspecies of coliform bacteria. Most *E. coli* are essential to the healthy life of all warm-blooded animals, including humans, but their presence in water is often indicative of fecal contamination. *E. coli* are used by the state of Idaho as the indicator for the presence of pathogenic microorganisms.
Ecology	The scientific study of relationships between organisms and their environment; also defined as the study of the structure and function of nature.
Ecological Indicator	A characteristic of an ecosystem that is related to, or derived from, a measure of a biotic or abiotic variable that can provide quantitative information on ecological structure and function. An indicator can contribute to a measure of integrity and sustainability. Ecological indicators are often used within the multimetric index framework.
Ecosystem	The interacting system of a biological community and its non-living (abiotic) environmental surroundings.
Effective Shade	That shade provided by all objects that intercept the sun as it makes its way across the sky.
Environment	The complete range of external conditions, physical and biological, that affect a particular organism or community.
Erosion	The wearing away of areas of the earth’s surface by water, wind, ice, and other forces.
Eutrophic	From Greek for “well nourished,” this describes a highly productive body of water in which nutrients do not limit algal growth. It is typified by high algal densities and low clarity.

Exceedance

A violation (according to DEQ policy) of the pollutant levels permitted by water quality criteria.

Existing Beneficial Use or Existing Use

A beneficial use actually attained in waters on or after November 28, 1975, whether or not the use is designated for the waters in Idaho's *Water Quality Standards and Wastewater Treatment Requirements* (IDAPA 58.01.02).

Existing Shade

Shade estimated to be provided to the stream under the current vegetative and topographic conditions.

Fauna

Animal life, especially the animals characteristic of a region, period, or special environment.

Fecal Coliform Bacteria

Bacteria found in the intestinal tracts of all warm-blooded animals or mammals. Their presence in water is an indicator of pollution and possible contamination by pathogens (also see Coliform Bacteria, *E. coli*, and Pathogens).

Flow

See *Discharge*.

Fully Supporting

In compliance with water quality standards and within the range of biological reference conditions for all designated and exiting beneficial uses as determined through the *Water Body Assessment Guidance* (Grafe *et al*. 2002).

Fully Supporting Cold Water

Reliable data indicate functioning, sustainable cold water biological assemblages (e.g., fish, macroinvertebrates, or algae), none of which have been modified significantly beyond the natural range of reference conditions.

Geographical Information Systems (GIS)

A georeferenced database.

Geometric Mean

A back-transformed mean of the logarithmically transformed numbers often used to describe highly variable, right-skewed data (a few large values), such as bacterial data.

Gradient

The slope of the land, water, or streambed surface.

Ground Water

Water found beneath the soil surface saturating the layer in which it is located. Most ground water originates as rainfall, is free to move under the influence of gravity, and usually emerges again as stream flow.

Growth Rate

A measure of how quickly something living will develop and grow, such as the amount of new plant or animal tissue produced per a given unit of time, or number of individuals added to a population.

Habitat

The living place of an organism or community.

Headwater

The origin or beginning of a stream.

Hydrologic Unit

One of a nested series of numbered and named watersheds arising from a national standardization of watershed delineation. The initial 1974 effort (USGS 1987) described four levels (region, subregion, accounting unit, cataloging unit) of watersheds throughout the United States. The fourth level is uniquely identified by an eight-digit code built of two-digit fields for each level in the classification. Originally termed a cataloging unit, fourth field hydrologic units have been more commonly called subbasins. Fifth and sixth field hydrologic units have since been delineated for much of the country and are known as watershed and subwatersheds, respectively.

Hydrologic Unit Code (HUC)

The number assigned to a hydrologic unit. Often used to refer to fourth field hydrologic units.

Hydrology

The science dealing with the properties, distribution, and circulation of water.

Inorganic

Materials not derived from biological sources.

Instantaneous

A condition or measurement at a moment (instant) in time.

Intergravel Dissolved Oxygen

The concentration of dissolved oxygen within spawning gravel. Consideration for determining spawning gravel includes species, water depth, velocity, and substrate.

Limiting Factor	A chemical or physical condition that determines the growth potential of an organism. This can result in a complete inhibition of growth, but typically results in less than maximum growth rates.
Limnology	The scientific study of fresh water, especially the history, geology, biology, physics, and chemistry of lakes.
Load Allocation (LA)	A portion of a water body’s load capacity for a given pollutant that is given to a particular nonpoint source (by class, type, or geographic area).
Load(ing)	The quantity of a substance entering a receiving stream, usually expressed in pounds or kilograms per day or tons per year. Loading is the product of flow (discharge) and concentration.
Load(ing) Capacity (LC)	A determination of how much pollutant a water body can receive over a given period without causing violations of state water quality standards. Upon allocation to various sources, and a margin of safety, it becomes a total maximum daily load.
Loam	Refers to a soil with a texture resulting from a relative balance of sand, silt, and clay. This balance imparts many desirable characteristics for agricultural use.
Loess	A uniform wind-blown deposit of silty material. Silty soils are among the most highly erodible.
Luxury Consumption	A phenomenon in which sufficient nutrients are available in either the sediments or the water column of a water body, such that aquatic plants take up and store an abundance in excess of the plants’ current needs.
Macroinvertebrate	An invertebrate animal (without a backbone) large enough to be seen without magnification and retained by a 500µm mesh (U.S. #30) screen.
Macrophytes	Rooted and floating vascular aquatic plants, commonly referred to as water weeds. These plants usually flower and bear seeds. Some forms, such as duckweed and coontail (*Ceratophyllum sp.*), are free-floating forms not rooted in sediment.

Margin of Safety (MOS)

An implicit or explicit portion of a water body's loading capacity set aside to allow the uncertainly about the relationship between the pollutant loads and the quality of the receiving water body. This is a required component of a total maximum daily load (TMDL) and is often incorporated into conservative assumptions used to develop the TMDL (generally within the calculations and/or models). The MOS is not allocated to any sources of pollution.

Mass Failures

A general term for the down slope movement of soil and rock material under the direct influence of gravity.

Mean

Describes the central tendency of a set of numbers. The arithmetic mean (calculated by adding all items in a list, then dividing by the number of items) is the statistic most familiar to most people.

Median

The middle number in a sequence of numbers. If there are an even number of numbers, the median is the average of the two middle numbers. For example, 4 is the median of 1, 2, 4, 14, 16; 6 is the median of 1, 2, 5, 7, 9, 11.

Metric

1) A discrete measure of something, such as an ecological indicator (e.g., number of distinct taxon). 2) The metric system of measurement.

Milligrams per Liter (mg/L)

A unit of measure for concentration. In water, it is essentially equivalent to parts per million (ppm).

Million Gallons per Day (MGD)

A unit of measure for the rate of discharge of water, often used to measure flow at wastewater treatment plants. One MGD is equal to 1.547 cubic feet per second.

Monitoring

A periodic or continuous measurement of the properties or conditions of some medium of interest, such as monitoring a water body.

Mouth

The location where flowing water enters into a larger water body.

National Pollution Discharge Elimination System (NPDES)
A national program established by the Clean Water Act for permitting point sources of pollution. Discharge of pollution from point sources is not allowed without a permit.

Natural Condition
The condition that exists with little or no anthropogenic influence.

Nitrogen
An element essential to plant growth, and thus is considered a nutrient.

Nonpoint Source
A dispersed source of pollutants, generated from a geographical area when pollutants are dissolved or suspended in runoff and then delivered into waters of the state. Nonpoint sources are without a discernable point or origin. They include, but are not limited to, irrigated and non-irrigated lands used for grazing, crop production, and silviculture; rural roads; construction and mining sites; log storage or rafting; and recreation sites.

Nuisance
Anything that is injurious to the public health or an obstruction to the free use, in the customary manner, of any waters of the state.

Nutrient
Any substance required by living things to grow. An element or its chemical forms essential to life, such as carbon, oxygen, nitrogen, and phosphorus. Commonly refers to those elements in short supply, such as nitrogen and phosphorus, which usually limit growth.

Organic Matter
Compounds manufactured by plants and animals that contain principally carbon.

Orthophosphate
A form of soluble inorganic phosphorus most readily used for algal growth.

Parameter
A variable, measurable property whose value is a determinant of the characteristics of a system, such as temperature, dissolved oxygen, and fish populations are parameters of a stream or lake.

Pathogens

A small subset of microorganisms (e.g., certain bacteria, viruses, and protozoa) that can cause sickness or death. Direct measurement of pathogen levels in surface water is difficult. Consequently, indicator bacteria that are often associated with pathogens are assessed. *E. coli*, a type of fecal coliform bacteria, are used by the state of Idaho as the indicator for the presence of pathogenic microorganisms.

Perennial Stream

A stream that flows year-around in most years.

Periphyton

Attached microflora (algae and diatoms) growing on the bottom of a water body or on submerged substrates, including larger plants.

pH

The negative $\log_{10}$ of the concentration of hydrogen ions, a measure which in water ranges from very acid (pH=1) to very alkaline (pH=14). A pH of 7 is neutral. Surface waters usually measure between pH 6 and 9.

Phosphorus

An element essential to plant growth, often in limited supply, and thus considered a nutrient.

Plankton

Microscopic algae (phytoplankton) and animals (zooplankton) that float freely in open water of lakes and oceans.

PNV Shade or Target Effective Shade

Shade generated by an intact riparian plant community that has grown to its fullest extent and has not been disturbed or reduced in anyway.

Point Source

A source of pollutants characterized by having a discrete conveyance, such as a pipe, ditch, or other identifiable “point” of discharge into a receiving water. Common point sources of pollution are industrial and municipal wastewater.

Pollutant

Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.

Pollution

A very broad concept that encompasses human-caused changes in the environment which alter the functioning of natural processes and produce undesirable environmental and health effects. This includes human-induced alteration of the physical, biological, chemical, and radiological integrity of water and other media.

Population

A group of interbreeding organisms occupying a particular space; the number of humans or other living creatures in a designated area.

Protocol

A series of formal steps for conducting a test or survey.

Qualitative

Descriptive of kind, type, or direction.

Quantitative

Descriptive of size, magnitude, or degree.

Reach

A stream section with fairly homogenous physical characteristics.

Reconnaissance

An exploratory or preliminary survey of an area.

Reference

A physical or chemical quantity whose value is known and thus is used to calibrate or standardize instruments.

Reference Condition

1) A condition that fully supports applicable beneficial uses with little affect from human activity and represents the highest level of support attainable. 2) A benchmark for populations of aquatic ecosystems used to describe desired conditions in a biological assessment and acceptable or unacceptable departures from them. The reference condition can be determined through examining regional reference sites, historical conditions, quantitative models, and expert judgment (Hughes 1995).

Reference Site

A specific locality on a water body that is minimally impaired and is representative of reference conditions for similar water bodies.

Respiration

A process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process converts organic matter to energy, carbon dioxide, water, and lesser constituents.

Riffle	A relatively shallow, gravelly area of a streambed with a locally fast current, recognized by surface choppiness. Also an area of higher streambed gradient and roughness.
Riparian	Associated with aquatic (stream, river, lake) habitats. Living or located on the bank of a water body.
River	A large, natural, or human-modified stream that flows in a defined course or channel or in a series of diverging and converging channels.
Runoff	The portion of rainfall, melted snow, or irrigation water that flows across the surface, through shallow underground zones (interflow), and through ground water to creates streams.
Sediments	Deposits of fragmented materials from weathered rocks and organic material that were suspended in, transported by, and eventually deposited by water or air.
Settleable Solids	The volume of material that settles out of one liter of water in one hour.
Species	1) A reproductively isolated aggregate of interbreeding organisms having common attributes and usually designated by a common name. 2) An organism belonging to such a category.
Stream	A natural water course containing flowing water, at least part of the year. Together with dissolved and suspended materials, a stream normally supports communities of plants and animals within the channel and the riparian vegetation zone.
Stream Order	Hierarchical ordering of streams based on the degree of branching. A first-order stream is an unforked or unbranched stream. Under Strahler's (1957) system, higher order streams result from the joining of two streams of the same order.
Subbasin	A large watershed of several hundred thousand acres. This is the name commonly given to 4^{th} field hydrologic units (also see Hydrologic Unit).

Subbasin Assessment (SBA)
A watershed-based problem assessment that is the first step in developing a total maximum daily load in Idaho.

Subwatershed
A smaller watershed area delineated within a larger watershed, often for purposes of describing and managing localized conditions. Also proposed for adoption as the formal name for 6th field hydrologic units.

Surface Water
All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors that are directly influenced by surface water.

Suspended Sediments
Fine material (usually sand size or smaller) that remains suspended by turbulence in the water column until deposited in areas of weaker current. These sediments cause turbidity and, when deposited, reduce living space within streambed gravels and can cover fish eggs or alevins.

Total Maximum Daily Load (TMDL)
A TMDL is a water body's load capacity after it has been allocated among pollutant sources. It can be expressed on a time basis other than daily if appropriate. Sediment loads, for example, are often calculated on an annual bases. A TMDL is equal to the load capacity, such that load capacity = margin of safety + natural background + load allocation + wasteload allocation = TMDL. In common usage, a TMDL also refers to the written document that contains the statement of loads and supporting analyses, often incorporating TMDLs for several water bodies and/or pollutants within a given watershed.

Total Suspended Solids (TSS)
The dry weight of material retained on a filter after filtration. Filter pore size and drying temperature can vary. American Public Health Association Standard Methods (Franson *et al*. 1998) call for using a filter of 2.0 microns or smaller; a 0.45 micron filter is also often used. This method calls for drying at a temperature of 103-105 °C.

Tributary
A stream feeding into a larger stream or lake.

Turbidity
A measure of the extent to which light passing through water is scattered by fine suspended materials. The effect of turbidity

depends on the size of the particles (the finer the particles, the greater the effect per unit weight) and the color of the particles.

Wasteload Allocation (WLA)

The portion of receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. Wasteload allocations specify how much pollutant each point source may release to a water body.

Water Body

A stream, river, lake, estuary, coastline, or other water feature, or portion thereof.

Water Column

Water between the interface with the air at the surface and the interface with the sediment layer at the bottom. The idea derives from a vertical series of measurements (oxygen, temperature, phosphorus) used to characterize water.

Water Pollution

Any alteration of the physical, thermal, chemical, biological, or radioactive properties of any waters of the state, or the discharge of any pollutant into the waters of the state, which will or is likely to create a nuisance or to render such waters harmful, detrimental, or injurious to public health, safety, or welfare; to fish and wildlife; or to domestic, commercial, industrial, recreational, aesthetic, or other beneficial uses.

Water Quality

A term used to describe the biological, chemical, and physical characteristics of water with respect to its suitability for a beneficial use.

Water Quality Criteria

Levels of water quality expected to render a body of water suitable for its designated uses. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, or industrial processes.

Water Quality Limited

A label that describes water bodies for which one or more water quality criterion is not met or beneficial uses are not fully supported. Water quality limited segments may or may not be on a §303(d) list.

Water Quality Limited Segment (WQLS)

Any segment placed on a state's §303(d) list for failure to meet applicable water quality standards, and/or is not expected to meet applicable water quality standards in the period prior to the next list. These segments are also referred to as “§303(d) listed.”

Water Quality Standards

State-adopted and U.S. Environmental Protection Agency-approved ambient standards for water bodies. The standards prescribe the use of the water body and establish the water quality criteria that must be met to protect designated uses.

Water Table

The upper surface of ground water; below this point, the soil is saturated with water.

Watershed

1) All the land which contributes runoff to a common point in a drainage network, or to a lake outlet. Watersheds are infinitely nested, and any large watershed is composed of smaller “subwatersheds.” 2) The whole geographic region which contributes water to a point of interest in a water body.

Water Body Identification Number (WBID)

A number that uniquely identifies a water body in Idaho and ties in to the Idaho water quality standards and GIS information.

Wetland

An area that is at least some of the time saturated by surface or ground water so as to support with vegetation adapted to saturated soil conditions. Examples include swamps, bogs, fens, and marshes.